

The influences of inorganic elements in soil on the development of famous - region *Atractylodes lancea* (Thunb.) DC

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ABSTRACT

Background: *Atractylodes lancea* (Thunb.) DC., is an important medicinal plant in China. Recently, researches of *A. Lancea* were focused on chemical composition and genetics, only a few were concerned with soil factors. **Objective:** The aim was to discuss the relationship between geo-herbalism of *A. Lancea* (Thunb.) DC. and inorganic elements in soil. **Materials and Methods:** The contents of 15 kinds of inorganic elements in the rhizoma of *A. Lancea* (Thunb.) DC. and soils from various regions were determined with inductively coupled plasma-optical emission spectrometer and the data were analyzed with Statistical Package for the Social Sciences 20.0 software. **Results:** The contents of inorganic elements in rhizoma of *A. Lancea* and in soil with different geological background were different. The soils in the famous region contained high aluminum, iron, sodium and low sulfur content. The rhizoma of *A. Lancea* contained high aluminum, lithium, manganese and low iron, sulfur content. The famous-region crude drugs had a strong tendency to accumulate selenium, manganese. Ten characteristic elements of *A. Lancea* were K, Ca, S, Al, Li, Ti, Mn, Pb, Ni, SE. **Conclusion:** The contents of inorganic elements in rhizoma of *A. Lancea* showed a significant positive interrelationship with those in soil. It was identified that inorganic elements play an important role in forming authenticity *A. Lancea* (Thunb.) DC.

Key words: *Atractylodes lancea* (Thunb.) DC, geo-herbalism, inductively coupled plasma-optical emission spectrometer, inorganic elements, soil

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INTRODUCTION

The plant of *Atractylodes lancea* (Thunb.) DC., Asteraceae, named CangZhu in China belongs to the Asteraceae family. Its rhizome, commonly called *Rhizoma atractylodis* is used as an important crude drug against rheumatic diseases, digestive disorders, night blindness and influenza in China.^[1] This medicine has been well-documented in Shen Nong Ben Cao Jing which is the first Chinese pharmacopoeia written in the Han dynasty about 200–100 BC.^[2] The rhizomes of two species, *A. lancea* (Thunb.) DC. and *A. Chinensis* (DC.) Koidz., named MaoCangZhu and BeiCangZhu in China separately, have been used as *R. atractylodis* that embodied in the Pharmacopoeia of People's Republic of China 2010. The *R. atractylodis* produced with *A. lancea* from Maoshan region of Jiangsu province have been considered to be the

“famous region drugs” with highest-quality and has been evidenced by long-term clinical practice.^[3] Nowadays, due to the scarcity of famous-region herbs from Maoshan, *R. atractylodis* have been produced with *A. lancea* other areas. Thus, in order to determine clinical efficacy, the quality control of *R. atractylodis* materials from different geographical origins is extremely important.

In recent years, many scholars have studied the geo-herbalism of *A. Lancea*,^[4] but only focusing on research of chemical composition and genetics.^[5-7] Zhao *et al.*^[8] analyzed the relationship between essential oil variation and genetic variation of *A. lancea*. The findings showed that the environmental factors also play an important role in the forming of the geoh herbs of *A. lancea* during the long-term adaptation, except for genetic factors. Guo *et al.*^[9] studied the influence of inorganic elements in soil on the geolism of *A. lancea*.

In our research, the contents of inorganic elements in 16 plants and soils samples of *A. lancea* from five provinces have been analyzed by using inductively coupled

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plasma-optical emission spectrometer (ICP-OES) in order to find out the characteristic elements of *A. lancea*, discuss the relationship between geo-herb alism of *A. lancea* (Thunb.) DC. and inorganic elements and provide the basis for causes, planting and management of famous-region *A. Lancea*.

MATERIALS AND METHODS

Equipment, reagents, and working conditions

The devices used here included an ICP-OES (Varian, USA), dual array solid-state charge coupled device detector projection optical system, RYTON material atomizer, 40 MHz solid-state high-frequency self-excited generator, polyscience circulating water cooling system. ICP-OES operating parameters were as follows: Radio frequency power (1150 W), auxiliary gas flow rate (0.5 L/min), nebulizer gas flow rate (26 L/min), and carrier gas flow (1.2 mL/min). Reagents included HCl, H₂O₂ and HNO₃, which were analytical pure.

Materials

Atractylodes lancea plants and soils were obtained from various geographical regions of China [Table 1]. All materials were identified to be the rhizomes of authentic *A. lancea* (Thunb.) DC., Asteraceae, by Professor Huangsheng Peng (School of Pharmacy, Anhui University of Chinese Medicine, Hefei, China). Samples were dried below 40°C and then crushed into a fine powder.

Sample preparation

Plant samples (200 mg) were digested with a mixture of concentrated HNO₃ (10 mL) and H₂O₂ (2 mL) at 180°C. Soil samples (200 mg) were digested with a mixture of concentrated HNO₃ (15 mL), HCl (5 mL) and H₂O₂ (5 mL) at 150°C. After digestion, the solution was evaporated to dryness on an electric heating board at 170°C. After cooling (20 min), digests were diluted and transferred into a volumetric flask and made up to 50 mL with ultrapure water. Concentrations of inorganic elements in plants and soils samples were determined with ICP-OES.

Statistical analysis

The correlation analysis, principal component analysis (PCA) and hierarchical clustering were performed with Statistical Package for the Social Sciences (SPSS) software (version 20.0, SPSS Inc., Chicago, USA). Our research selected the Ward's method.^[10,11] In other words, during the clustering process, two subclasses that make the minimum increase of the total sum of squares of Euclidean distance among all samples of all subclass were combined into a single subclass. The Squared Euclidean Distance was selected as a measurement.

Table 1: Origin of the medical materials

Population	Number of plant	Number of soil
Tongbai, Henan	A1	S1
Luanchuan, Henan	A2	S2
Lushi, Henan	A3	S3
Suizhou, Hubei	A4	S4
Baokang, Hubei	A5	S5
Songluo, Hubei	A6	S6
Songluo, Hubei	A7	S7
Zhenan, Shanxi	A8	S8
Xunyi, Shanxi	A9	S9
Huoshan, Anhui	A10	S10
Tongcheng, Anhui	A11	S11
Qianshan, Anhui	A12	S12
Maoshan, Jiangsu*	A13	S13
Mageng, Jiangsu*	A14	S14
Fangshan, Jiangsu*	A15	S15
Wawushan, Jiangsu*	A16	S16

*Famous region

RESULTS AND DISCUSSION

Contents of inorganic elements in soils

There were differences among contents of inorganic elements in soils from different regions. Results showed that the soils in the famous region contained more Na, Cr, Fe, Ni, B and less S than unfamous regions. Comparing mean values, we found that contents of Al in famous-region soils were higher than unfamous-region that may be associated with the formation of traditional famous region. The contents of Al, Fe, Na may be used as the identification characteristics of the famous-region soil [Table 2].

Contents of inorganic elements in plants

Content analysis

There were differences among contents of inorganic elements in plants from different regions. Results showed that famous-region herbs contained more Al, Li, P, Mn and less S, K, Fe than unfamous-region. Comparing mean values, we found that contents of Ti, Se, Pb in famous-region herbs were higher than unfamous-region. The famous-region *A. lancea* contained high Al, K, Ca [Table 3].

Rhizoma atractylodis belongs to the warm medicine. The substantial inorganic elements base of heat nature of Chinese herbs is decided by high Mn and low Fe.^[12] Comparing Fe/Mn among famous-region and unfamous-region plants, we found that the Fe/Mn values of famous-region herbs were significantly lower than unfamous-region which manifested the inorganic elements characteristics of high Mn and low Fe.

Principal component analysis

We used SPSS (version 20.0, SPSS Inc., Chicago, USA) for the PCA, and three principal components were obtained. Among

Table 2: Contents of inorganic elements in soils (mg/kg)

Sample	Aluminum	Lithium	Sulfur	Phosphorus	Sodium	Potassium	Calcium	Titanium	Chromium	Manganese	Iron	Nickel	Selenium	Lead	Boron
S1	13218.5	26.7475	261.225	164.8025	1854.725	5194.25	3743.75	393.95	16.48225	159.7875	8044.5	15.1545	1.1775	16.773	103.39
S2	13469.75	39.3525	72.8125	125.0475	1377.95	4559	2859.75	351.775	24.627	232.9225	10534	25.855	0.1495	20.73975	65.09
S3	11833	35.97	84.725	75.2225	1519.4	4925.5	1515.3	385.95	28.79	130.0625	7363.5	32.5975	2.34075	13.23075	52.55
S4	11113	22.5765	152.4925	120.6925	1875.7	5473.75	2867	266.25	9.472	158.52	4943.25	14.579	0.628	17.3875	48.0025
S5	8043.75	31.2275	136.3025	193.85	1668.825	3927.25	1804.075	55.3625	10.73725	229.6475	5065.5	18.18925	0.04575	15.01	84.1725
S6	9661	32.5875	215.255	182.995	1729.625	4686.5	1877.65	18.05975	13.76725	247.7375	7317.75	21.2295	3.7815	13.75825	91.01
S7	7697	30.1875	268.65	231.95	1707.65	4055.25	3275	198.005	20.2545	148.3575	6662.25	14.23725	0.1695	13.81375	56.125
S8	10559.75	29.2075	426.6	327.65	1965.025	5194.25	7895.5	43.4275	15.07925	192.35	8547.25	26.16	3.436	22.73	100.2025
S9	11909.5	40.59	193.5875	213.7825	1508.8	5792.25	4525.75	129.3175	19.1575	273.3	8995.5	24.6775	1.0725	15.1205	88.045
S10	10252	7.52375	76.0925	88.715	1548.65	3482.75	1676.3	302.65	15.44375	259.95	7740	16.89875	2.1065	26.3725	88.885
S11	6387	7.50175	82.0075	170.2125	1480.65	3584.5	2135.15	494.15	10.97925	131.12	5648	10.75525	1.85075	23.6075	52.815
S12	10347	9.4055	122.97	82.7725	1347.5	1668.275	1268.7	128.2475	8.149	212.56	4788.75	8.87025	5.7275	23.6075	51.18
S13	14411.25	25.8175	10.44925	116.675	2317.6	3539	2532.25	145.5775	34.16	345.275	12970	30.925	0.27075	21.64225	130.1525
S14	13442.25	23.15825	14.253	181.885	2442.425	3532	1945.05	134.9425	35.8525	265.925	12117	31.4025	0.3425	17.20225	131.655
S15	13305.25	26.595	18.72475	285.2	2793.5	4543.75	2940.25	258.95	30.2725	193.285	10579.75	32.85	0.366	30.3275	126.1425
S16	16488	35.89	12.53125	142.835	2051.55	4162	2770.25	182.4275	36.7325	285.95	13098.25	32.095	0.307	18.48075	129.1675
Mean	11383.625	26.52114063	134.2923906	169.0179688	1824.348438	4270.017188	2851.420313	218.0651406	20.62228125	216.671875	8400.953125	22.27976563	1.48575	19.36273438	87.4115625
Maximum	16488	40.59	426.6	327.65	2793.5	5792.25	7895.5	494.15	36.7325	345.275	13098.25	32.85	5.7275	30.3275	131.655
Minimum	6387	7.50175	10.44925	75.2225	1347.5	1668.275	1268.7	18.05975	8.149	130.0625	4788.75	8.87025	0.04575	13.23075	48.0025
SD	2672.523709	10.52683865	115.5934837	71.18143916	408.2219868	1011.574834	1599.898309	139.3131203	9.815676633	61.91467072	2780.480659	8.327664205	1.639831511	5.010849757	30.79826464
Variation	7142382.975	110.8164374	13361.85347	5066.79728	166645.1905	1023283.848	2559674.598	19408.14547	96.34750776	3833.42645	7731072.693	69.34999111	2.689047383	25.10861529	948.5331049

SD: Standard deviation

Table 3: Contents of inorganic elements in herbs (mg/kg)

Sample	Aluminum	Lithium	Sulfur	Phosphorus	Sodium	Potassium	Calcium	Titanium	Chromium	Manganese	Iron	Nickel	Selenium	Lead	Boron
A1	1755.925	3.13475	75.62	159.975	1390.375	6166.75	3443.5	28.3375	1.68725	37.1425	1557.35	5.5175	2.60875	3.78625	38.6975
A2	1357.425	4.546	672.1	492.275	1733.775	11763.75	5307.25	4.902	15.2975	28.6325	1682.225	7.1445	2.96725	2.21125	120.1775
A3	6.125	2.4775	735.75	6.8225	3156.25	9067.25	4241	0.09125	0.738	35.6225	1503.082	9.608	2.0475	0.50725	98.3825
A4	536.225	2.056	424.575	154.44	1522.75	11550	5416	0.989	10.225	29.52	2099.125	5.282	0.0355	2.09875	79.6725
A5	1448.125	4.3335	654.575	538.2	2196.425	7786.25	4109.75	19.18775	5.28525	8.3075	2103.4	16.22825	1.16875	5.1635	115.045
A6	1859.65	5.521	565.75	298.5	2320.95	7341.25	4706.25	12.3815	7.342	13.7375	2282.875	14.81475	3.031	5.94525	111.67
A7	987.925	2.866	417.5	411.7	1723.325	12747.75	3381.75	16.59125	2.437	16.16325	1183.8	5.41125	1.83225	4.151	31.2525
A8	519.875	4.2125	162.2325	322.505	1345.75	7263.25	5582.25	9.375	4.6425	28.2375	1969.05	6.44425	7.17075	5.55	180.9312
A9	515.375	2.50225	318.1	195.39	1656.05	7150.75	4477.25	8.407	8.29875	23.27175	834.25	5.137	1.882	3.025	116.5425
A10	1434.45	2.138	968.9	301.75	2486.675	10524	6243	58.0225	6.8575	34.98	1831.25	19.614	1.14475	18.19375	83.8575
A11	398.625	1.6295	764	455.85	2074.875	12383.25	3166	0.71675	5.90825	29.4075	1269.975	11.9915	1.6625	4.006	120.9925
A12	370.2	1.60025	585.6	540.575	1507.75	8513.5	4921	10.81325	13.26375	32.555	1219.675	5.672	4.21775	6.2	124.135
A13	3837.25	8.43625	22.2515	558.025	1714.175	4894.75	3405	36.73	6.177	112.5025	901.5	12.7065	5.6715	6.6115	120.9625
A14	3054.25	7.26975	36.2075	548.475	2132.775	5131	3728.25	28.7525	5.09	93.3975	163.5	13.0545	4.46675	9.61775	100.67
A15	2999	6.68425	46.85	566	1897.25	5170.75	3748.75	31.3375	5.55975	96.97	197	13.1445	7.24	8.1655	94.3825
A16	3470.75	8.3	46.77	590.45	1958.975	5166.5	3629.25	37.065	5.51775	101.855	420.5	11.963	6.357	7.62075	98.9725
Mean	1534.44838	4.23171875	406.0488438	383.8082813	1926.132813	8288.796875	4344.140625	18.98123438	6.520453125	45.14390625	1326.159813	10.23334375	3.344	5.80334375	102.2714813
Maximum	3837.25	8.43625	968.9	590.45	3156.25	12747.75	6243	58.0225	15.2975	112.5025	2282.875	19.614	7.24	18.19375	180.9312
Minimum	6.125	1.60025	22.2515	6.8225	1345.75	4894.75	3166	0.09125	0.738	8.3075	163.5	5.137	0.0355	0.50725	31.2525
SD	1212.567886	2.356075945	312.2981424	182.1367325	467.6692753	2756.480075	931.4668896	16.40009322	3.857236536	34.54069456	678.2777609	4.579908069	2.259329362	4.088056505	34.8012659
Variation	1470320.877	5.546382707	97530.12975	33173.78932	218714.5511	7598182.402	867630.5664	268.9630577	14.878273689	1193.059581	460060.7209	20.97555792	5.104569167	16.71220599	1211.128108

SD: Standard deviation

them, the contribution rate of the first and second principal components was 47.87% and 22.48%, respectively, and a cumulative contribution rate of 94.53%. The first principal component were K, Li, S, Al, Mn, Se and the second principal component Ca, and the third principal component Ti, Pb, Ni [Table 4]. We can conclude that 10 kinds of characteristic elements of *A. lancea* were K, Ca, S, Al, Li, Ti, Mn, Pb, Ni, Se.

By using the percentage of variance of each principal component, we calculated the comprehensive scoring formula: $F = 0.47872 F_1 + 0.22486 F_2 + 0.24175 F_3$. The comprehensive factor score and sorting of *A. lancea* from different regions were shown in Table 5. The score of Maoshan Jiangsu, Huoshan Anhui, Wawushan Jiangsu, Mageng Jiangsu, Fangshan Jiangsu ranked 1–5, proving that the famous-region *A. lancea* conformed to the above characteristics of inorganic element. Four famous-region herbs contained high K, Al, Li, Ti, Mn, Se, Pb and low S, Ca. The *A. lancea* from Huoshan Anhui contained high K, S, Ti, Pb, Ca. However, the score of Tongcheng Anhui was lowest, and the *A. lancea* from Tongcheng contained low Li, Ti, Pb.

The first two principal components were used to build the scatter diagram [Figure 1]. The samples were divided into two groups: Group 1 contained four samples as famous-region *A. lancea*; group 2 included 12 samples of unfamous-region *A. lancea*.

Correlation analysis

The correlation analysis among 15 kinds of inorganic elements was conducted [Table 6]. Results showed that Al with Mn, S with K and Ni with Pb etc., ($P < 0.01$) were significantly correlated. Mn with P etc., ($P < 0.05$) were correlated. It might indicate that the absorption of these

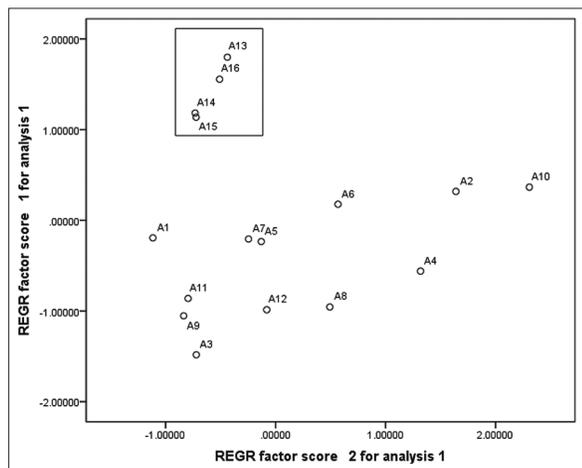


Figure 1: Principal component analysis results of the 16 *Atractylodes lancea* samples. We used Statistical Package for the Social Sciences for the normalization data processing, and the extraction standard was the characteristic value of >1. The first two principal components were used to build the scatter diagram

Table 4: Component loading matrix

	Aluminum	Lithium	Titanium	Manganese	Phosphorus	Nickel	Lead	Selenium	Boron	Potassium	Sulfur	Calcium	Iron	Chromium	Sodium
	0.760	0.785	0.485	0.728	0.333	0.240	0.231	0.705	0.158	-0.99	-0.770	-0.36	-0.57	-0.26	-0.08
	-0.455	-0.34	-0.14	-0.38	-0.47	0.095	0.075	-0.03	0.462	-0.11	0.225	0.784	0.210	0.240	0.003
	0.468	0.367	0.547	0.223	0.295	0.516	0.580	0.020	-0.03	0.039	0.134	0.468	0.259	0.411	0.071

elements was accumulated (namely certain homogeneity). On the contrary, K with Al and S with Se ($P < 0.01$), etc., were significantly negatively correlated. Fe with Se ($P < 0.05$) was negatively correlated.

Cluster analysis

The results were processed by SPSS cluster analysis [Figure 2]. The 16 samples could be gathered into two groups: Famous-region *A. lancea* were clustered into a group; unfamous-region *A. lancea* were clustered into a group. The cluster analysis outcomes were consistent with those of the PCA.

Correlation analysis between plants and soils

Correlation coefficient

The inorganic elements of *A. Lancea* from Luanchuan Henan,

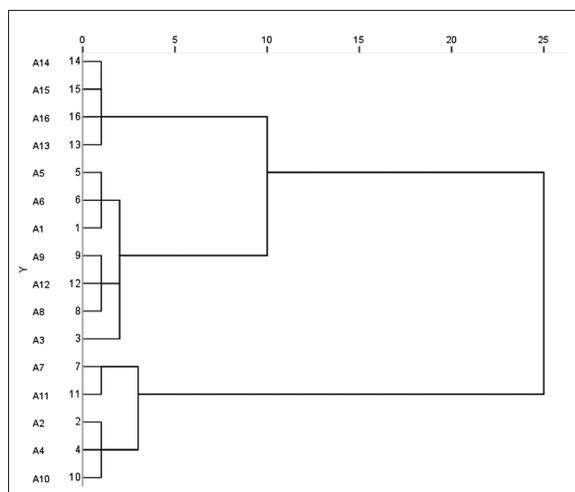


Figure 2: Cluster analysis results of the 16 *Atractylodes lancea* samples using Statistical Package for the Social Sciences software. Ward's method was applied and the squared Euclidean distance was chosen as the measurement

Table 5: The comprehensive factor score and sorting

Population	F1	F2	F3	F	Rank
Tongbai, Henan	-0.19	-1.11	0.46	-0.23	11
Luanchuan, Henan	0.31	1.63	-0.88	0.30	7
Lushi, Henan	-1.48	-0.72	0.178	-0.82	15
Suizhou, Hubei	-0.56	1.31	-0.34	-0.05	9
Baokang, Hubei	-0.23	-0.13	0.31	-0.06	10
Songluo, Hubei	0.17	0.56	0.73	0.39	6
Songluo, Hubei	-0.20	-0.24	-2.31	-0.71	14
Zhenan, Shanxi	-0.95	0.49	1.59	0.04	8
Xunyi, Shanxi	-1.05	-0.83	0.79	-0.50	13
Huoshan, Anhui	0.36	2.30	0.17	0.73	2
Tongcheng, Anhui	-0.86	-0.79	-2.04	-1.08	16
Qianshan, Anhui	-0.98	-0.08	0.56	-0.35	12
Maoshan, Jiangsu	1.79	-0.43	0.11	0.79	1
Mageng, Jiangsu	1.18	-0.73	0.25	0.46	4
Fangshan, Jiangsu	1.13	-0.72	0.27	0.45	5
Wawushan, Jiangsu	1.55	-0.51	0.11	0.65	3

Table 6: Correlation analysis among the inorganic elements of plants

	Aluminum	Lithium	Sulfur	Phosphorus	Sodium	Potassium	Calcium	Titanium	Chromium	Manganese	Iron	Nickel	Selenium	Lead	Boron
Aluminum	1														
Lithium	0.922**	1													
Sulfur	-0.637**	-0.676**	1												
Phosphorus	0.603*	0.579*	-0.268	1											
Sodium	-0.044	-0.007	0.509*	-0.223	1										
Potassium	-0.686**	-0.725**	0.739**	-0.261	0.073	1									
Calcium	-0.407	-0.364	0.464	-0.302	-0.004	0.299	1								
Titanium	0.691**	0.460	-0.241	0.349	0.080	-0.443	-0.021	1							
Chromium	-0.118	0.114	0.261	0.292	-0.341	0.260	0.511*	-0.215	1						
Manganese	0.839**	0.796**	-0.679**	0.499*	-0.022	-0.663**	-0.405	0.542*	-0.128	1					
Iron	-0.559*	-0.509*	0.595*	-0.480	0.055	0.489	0.567*	-0.327	0.139	-0.779**	1				
Nickel	0.456	0.365	0.252	0.328	0.616*	-0.217	0.026	0.606*	-0.162	0.257	-0.008	1			
Selenium	0.570*	0.698**	-0.683**	0.515*	-0.262	-0.683**	-0.182	0.286	-0.066	0.682**	-0.532*	0.035	1		
Lead	0.418	0.218	0.064	0.339	0.174	-0.210	0.282	0.855**	-0.015	0.320	-0.174	0.699**	0.187	1	
Boron	-0.102	0.154	0.032	0.228	-0.057	-0.203	0.339	-0.262	0.347	0.025	0.111	0.094	0.429	-0.023	1

*P<0.05 correlated; **P<0.01 significantly correlated

Lushi Henan, Huoshan Anhui, Tongcheng Anhui, Qianshan Anhui were not correlated with corresponding soil. On the contrary, the inorganic elements from 11 other regions were obviously related [Table 7]. The results of our study were not the same with Guo *et al.*^[9] which may be related to the quantities of samples. Thus, we speculated that *A. lancea* absorbed inorganic elements from the soil in two ways: Selective absorption (active absorption) and passive absorption.

Enrichment coefficient

Enrichment coefficient (EC) is the EC for plant/soil system. It was calculated to assess the accumulations of elements from soils to plants, and it is described as the following formula:^[13]

$$EC = \frac{[M]_{\text{plant}}}{[M]_{\text{soil}}}$$

$[M]_{\text{plant}}$ is the concentration of an element in the tissue of the plant (root or leaf), mg/kg, in dry matter;

$[M]_{\text{soil}}$ is the total concentrations of an element in soils where this plant is grown, mg/kg, in dry matter.

Famous-region *A. lancea* had a strong tendency to accumulate Se (average value 18.6) and good tendency to S, P, K, and Ca. However, the EC of other elements was low (<1). The EC of Fe of famous-region herbs was 8.3 times lower than unfamous-region herbs. But the EC of Se, Mn was 3.4 times and 2.5 times higher, respectively. This was probably due to the selective absorption and enrichment of some trace elements with medicinal plants regulating the body metabolism.^[14] Therefore,

EC characteristics can be used as a chemical feature of identifying famous-region *A. lancea*.

CONCLUSION

The contents of inorganic elements in rhizoma of *A. lancea* and in soil with different geological background were different. Content analysis, correlation analysis, and enrichment analysis proved that famous-region herbs had a good tendency to accumulate Mn and bad to Fe which played an important role in the formation of the traditional famous-region *R. atractylodis*. The inorganic elements are one of the important causes of formation of famous-region *R. atractylodis*. Inorganic elements in *R. atractylodis* are closely related to those in soil.

By the results of the correlation analysis among 15 kinds of inorganic elements that toxic element Pb with essential element Ni etc., were significantly correlated and the absorption of these elements was accumulated, we may speculate that the influence of inorganic elements on the formation of famous-region herbs was not just about how much the content of them, but also about the contribution to growth, formation and effective components. These aspects need further research.

The results of PCA and clustering analysis showed that the inorganic element may be used as a standard to identify famous-region plants. Therefore, in addition to the traditional chemical method, the characteristics of inorganic elements may also be the basis of geo-authentic and effective characteristics research of traditional Chinese medicine.

Table 7: Correlation analysis between plants and soils

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
S1	0.572***															
S2		0.343														
S3			0.307													
S4				0.458*												
S5					0.550**											
S6						0.565**										
S7							0.438*									
S8								0.603**								
S9									0.441*							
S10										0.35						
S11											0.411					
S12												0.15				
S13													0.581**			
S14														0.433*		
S15															0.529*	
S16																0.517*

* $P < 0.05$ correlated; ** $P < 0.01$ significantly correlated

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REFERENCES

1. Tang W, Eisenbrand G. Chinese Drugs of Plant Origin: Chemistry, Pharmacology, and Use in Traditional and Modern Medicine. Berlin and New York: Springer; 1992.
2. Editorial Committee of National Chinese Medical Manage Bureau Chinese Herb. Chinese Herb. Shanghai: Shanghai Science and Technology Publisher; 1999. p. 519.
3. Hu SL. The textual research of materia medica on *Rhizoma Atractylodis*. Chin J Trad Chin Med Pharm 2001;16:11-3.
4. Takeda O, Miki E, Terabayashi S, Okada M, Lu Y, He HS, *et al.* A comparative study on essential oil components of wild and cultivated *Atractylodes lancea* and *A. chinensis*. Planta Med 1996;62:444-9.
5. Guo LP, Liu JY, Ji L, Huang LQ. The naphtha composing characteristics of geoherb of *Atractylodes lancea*. Zhongguo Zhong Yao Za Zhi 2002;27:814-9.
6. Ouyang Z, Yang L, Su SL, Han L, Xia B, Wang M. GC-MS analyzing the volatile components of *Atractylodes lancea* (Thunb.) DC. with supercritical CO₂ fluid extraction. Chin J Pharm Anal 2007;27:1333-9.
7. Ouyang Z, Yang L, Su SL, Feng X, Wang M. Fingerprint of volatile oil of *Atractylodes lancea* by GC-MS. Yao Xue Xue Bao 2007;42:968-72.
8. Zhao QH, Guo LP, Huang LQ, Zhang XB. Relationship between essential oil variation and genetic variation of *Atractylodes lancea*. Resour Sci 2008;30:765.
9. Guo LP, Huang LQ, Yan YN. The influences of inorganic elements in soil on the geolism of *Atractylodes lancea*. Zhongguo Zhong Yao Za Zhi 2002;27:245-50.
10. Liu ZH, Ye TX, Zhao HZ, Guo YZ, Cheng Y. Fingerprint and chemical pattern recognition method for quality control of Huoxiang Zhengqi liquid. Chin J Pharm Anal 2012;32:2064-67.
11. Nie L, Luo GA, Cao J, Wang YM. Pattern recognition applied to the fingerprint of traditional Chinese medicine characterized by two-dimension information data. Yao Xue Xue Bao 2004;39:136-9.
12. Yang B, Wang ZG. Literature study on relationship between cold-heat nature of plant-based chinese herbs and inorganic elements. J Nanjing TCM Univ 2011;27:109-11.
13. Antoniadis V, Alloway BJ. Availability of Cd, Ni and Zn to ryegrass in sewage sludge-treated soil at different temperatures. Water Air Soil Pollut 2001;132:201.
14. Kacálková L, Tlustoš P, Száková J. Phytoextraction of cadmium, copper, zinc and mercury by selected plants. Plant Soil Environ 2009;55:295-304.

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